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2019

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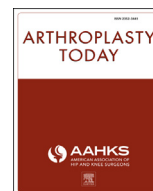
Recommended Citation

Mercer N, Hawkins E, Menken L, Deshmukh A, Rathod P, Rodriguez JA. Optimum anatomic socket position and sizing for the direct anterior approach: impingement and instability. . 2019 Jan 01; 5(2):Article 5515 [p.]. Available from: <https://academicworks.medicine.hofstra.edu/articles/5515>. Free full text article.

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Surgical technique

Optimum anatomic socket position and sizing for the direct anterior approach: impingement and instability

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ARTICLE INFO

Article history:

Received 1 November 2018

Received in revised form

8 January 2019

Accepted 13 January 2019

Available online 5 March 2019

Keywords:

Total hip arthroplasty

Acetabular size

Acetabular positioning

Impingement

Dislocation

ABSTRACT

A comprehensive strategy is important for ensuring reproducible and safe acetabular component sizing and positioning. Presented here is our approach for anatomic acetabular component positioning in direct anterior total hip arthroplasty. This strategy has evolved with our understanding of the ramifications of socket sizing and positioning on instability and impingement. Data collected by a single surgeon (J.A.R.) between 2009 and 2011 influenced our current paradigm. We compare the sizing and positioning parameters of the anterior and posterior approach, thus demonstrating how the 2 are different. By highlighting these differences, we hope to provide a clear, defined approach to acetabular placement and sizing for direct anterior-approach total hip arthroplasty.

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Introduction

Transitioning from a posterior approach (PA) of the hip to a direct anterior approach (DAA) can be a challenge for orthopedic surgeons performing total hip arthroplasty (THA) [1,2]. There are well-established concepts and practices for acetabular component insertion through the PA [3,4]. The number of THAs that use the DAA is increasing, so it is important to understand the complications and potential pitfalls of this approach [5]. One such pitfall is suboptimal positioning and sizing of the acetabular component.

In addition, safety issues for patients remain a concern when surgeons are transitioning to the anterior approach [6]. For this reason, a comprehensive strategy is important for ensuring reproducible and safe acetabular component positioning. We believe the

goals for optimizing cup positioning and sizing in the anterior approach are different compared with those in the PA. In this article, we have illustrated an efficient and reproducible way to ensure optimal cup positioning and sizing for the DAA and describe the clinical basis for this thought process.

Surgical technique

Background

We performed a retrospective analysis of all primary anterior cementless THA procedures performed at our institution by a single surgeon (J.A.R.) between 2009 and 2011. The surgeries comprised the first 300 DAA THAs performed by the surgeon after his transition from the PA. We divided the patients into 3 consecutive groups based on an evolving strategy of cup sizing and positioning. In group A, for the first 100 DAA THAs performed by the senior surgeon, cup anteversion and sizing goals [3] were similar to those of PA THA, (average, 24.3 deg of anteversion), and no stability testing was performed intraoperatively. In group B, in the second set of 100 surgeries performed by the senior surgeon, cup anteversion was modified based on intraoperative stability assessment and was significantly lower (average, 12.5 deg of anteversion). In group C, in the final 100 surgeries performed during the transition period, cup

One or more of the authors of this article have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to <https://doi.org/10.1016/j.artd.2019.01.003>.

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<https://doi.org/10.1016/j.artd.2019.01.003>

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Table 1

Results from retrospective analysis between groups.

Post-op parameters	Group A	Group B	Group C
Dislocation	2	0	0
Groin pain due to Psoas impingement	2	12	2
Abduction (degrees)	39.75 (4.4)	41.1 (3.8)	38.1 (4.0)
Anteversion (degrees)	24.3 (7.5), $P < .01$	12.5 (3.3)	13.6 (2.3)
Cup size difference (mm)	5.16 (2.13)	5.7 (2.6)	1.4 (1.4), $P < .01$

Group A consists of the first 100 surgeries, group B consists of the next 100 surgeries, and group C consists of the last 100 surgeries.

sizing was diminished to avoid anterior overhang and minimize posterior overhang by direct visual observation. As such, the average cup size in group C was, on average, 4 mm smaller than that in groups A and B. In group A, there were 2 anterior dislocations (both cups had an anteversion of 28 degrees). In group B, there were no dislocations, but 12 patients developed groin pain due to iliopsoas impingement. In group C, 2 patients developed groin pain, and there were no dislocations (Table 1). The results of this analysis molded the strategy for cup positioning and sizing we use today. Its goal is to optimize the cup position and reduce the likelihood of iliopsoas tendon impingement and instability through visual inspection and provocative stability testing.

Preoperative planning

A standing anteroposterior of the pelvis, centered on the pubic symphysis, is obtained for every patient who will undergo surgery. The teardrops and posterior cotyledons are marked, and a horizontal reference line is drawn between the bases of the teardrops. Then, the anterior and posterior walls of the acetabulum are identified and marked noting the appearance of the ellipse (Fig. 1a). Cup size is chosen to match the native acetabular size, which is initially estimated at 4 mm that is larger than the native femoral head size as measured on a false-profile radiograph of the pelvis. The cup position is templated so that the superior contact point coincides with the superolateral margin of the acetabular subchondral bone. The inferomedial corner of the cup is templated at or just below the inter teardrop line. Medialization position is chosen at the lateral teardrop or slightly more lateral depending on bone morphology. Each of these points is marked, and the cup template is brought into contact with each of the 3 points as the final cup size and position are estimated.

Acetabular preparation and cup positioning

After acetabular exposure and labral resection, the contents of the cotyloid fossa are removed to clearly see the medial wall of the acetabulum. Reaming begins with a reamer 2 mm smaller than the templated cup size, with the initial focus on medialization to within 1 mm of the templated medial point.

A fluoroscopic image is taken with the goal of reproducing the appearance of the patient's standing anteroposterior pelvis. The surgeon should ensure that the rotation of the pelvis is neutralized in the axial plane. The patient's standing pelvic tilt should be reproduced as well using the appearance of the obturator foramen as a guide. It should be noted that if a more lordotic pelvic position is seen in this fluoroscopic image, the cup will appear to be flatter and less anteverted. Conversely, if the obliquity of the radiograph beam creates a flat back appearance, the cup will appear more anteverted in the image. In either case, if the image reproduces the appearance of the preoperative standing pelvis, then it represents the actual position of the pelvis when standing and walking and thus is the position that should be used to evaluate the socket position.

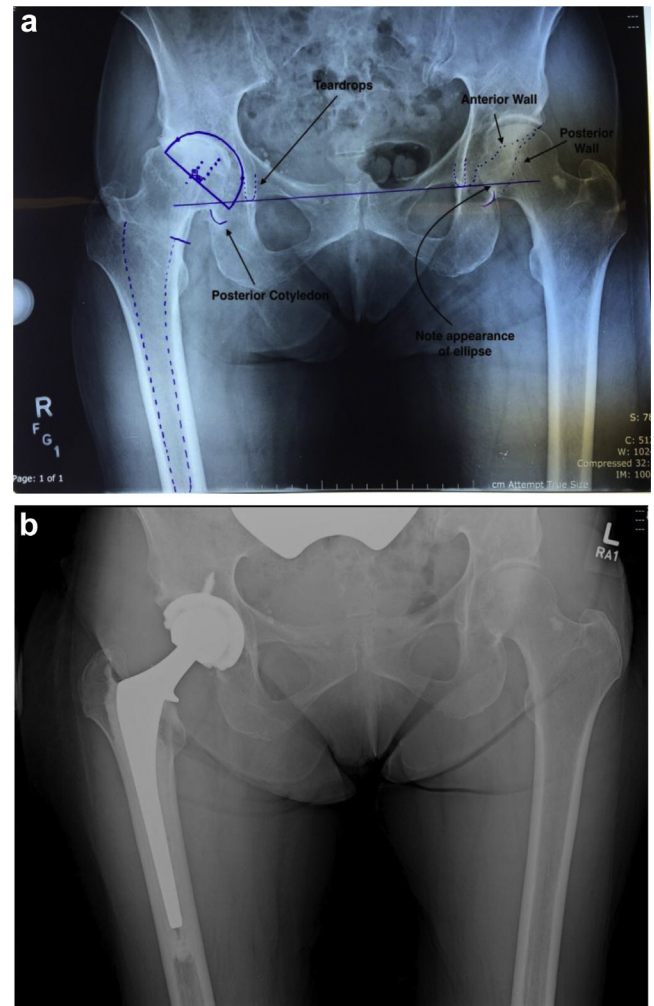


Figure 1. (a) Preoperative plan for right total hip arthroplasty. (b) Standing anteroposterior showing the final postoperative result.

With the reamer in position, medialization as well as superior and inferior points are evaluated, with the image intensified and compared to the preoperative plan. Once these points are reached, attention is paid to optimizing cup abduction and anteversion. The final reamer is positioned so that the anterior edge of the reamer is

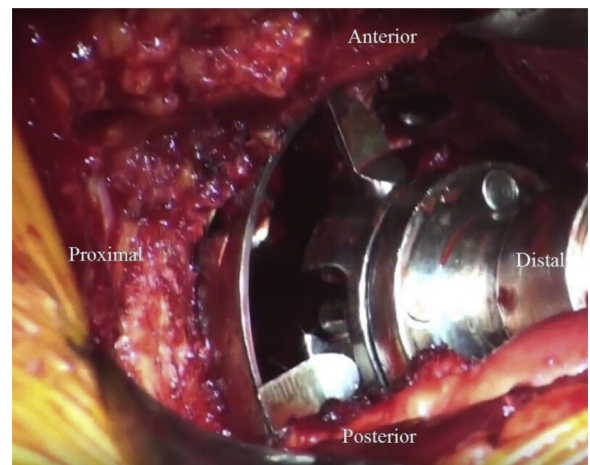


Figure 2. The final reamer is positioned flush with the anterior wall and protrudes 2–3 mm posteriorly.

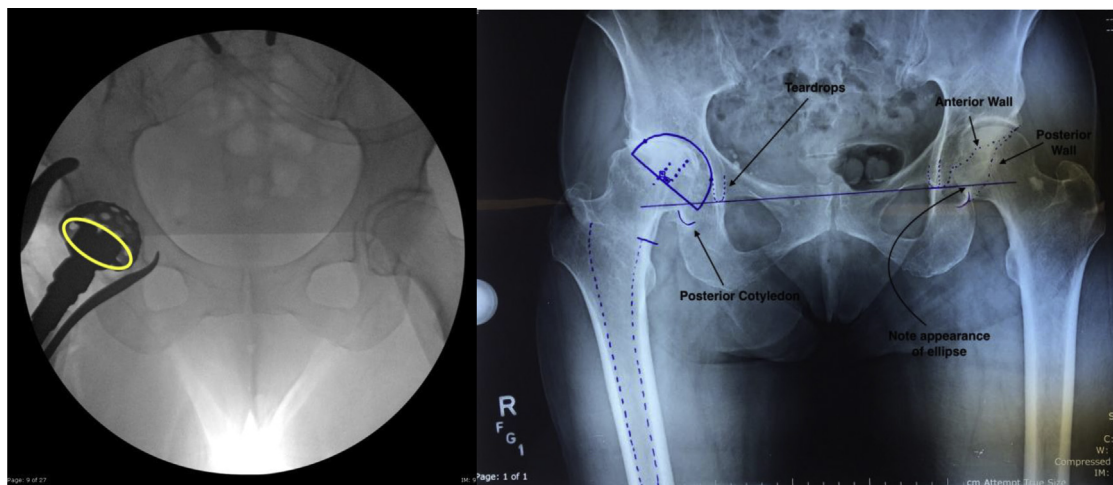


Figure 3. Once the final reamer's abduction, anteversion, and position is optimized with respect to the anterior and posterior walls, a final shot is saved and used for comparison when implanting the cup.

at or just inside the anterior wall. Direct visualization and manual palpation are used to verify this position. When properly sized, the posterior edge of the reamer should extend no more than 2–3 mm beyond the posterior wall (Fig. 2). A fluoroscopic image with the final reamer in the optimized position is taken (Fig. 3). This allows a final verification of anteversion and abduction. The ellipse created by the open reamer face is evaluated and compared to the position of the anterior and posterior walls on the preoperative plan. The cup is then implanted in the same version and abduction as the final reamer. Fluoroscopy and direct visualization and manual palpation of the anterior edge of the cup are used to verify anatomic cup positioning as previously described. Posteriorly, the actual acetabular component cup will protrude 1–2 mm beyond the final reamer position (Fig. 4). The prosthetic socket is a more complete hemisphere than most reamers, which accounts for the difference in posterior overhang between the reamer cup and trial cup given the identical anterior position of the socket relative to the anterior wall (Fig. 5). Nonetheless, the cup should not protrude more than 3–4 mm from the posterior wall to minimize the potential for posterior impingement and anterior subluxation (Fig. 6). Provocative testing in full extension and hyperextension is performed to assess for impingement of the femoral neck on the socket edge.

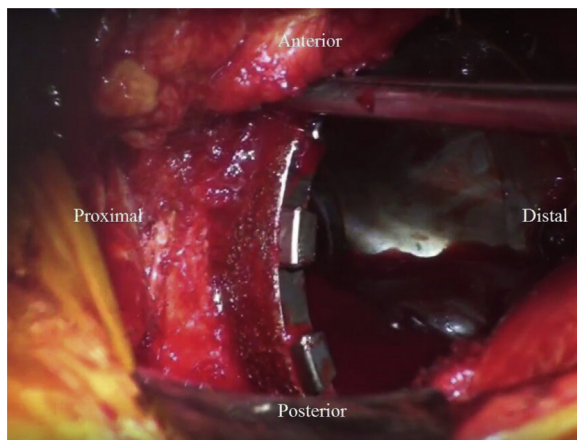


Figure 4. The implanted cup should extend approximately 1 mm further posteriorly than the final reamer position but should remain at or just inside the anterior wall. (Crown Cup, Exactech, Gainesville, FL).

Stability evaluation

We perform a DAA THA on a standard operating table, with both legs prepped into the surgical field. This allows for direct limb length evaluation and comparison and more readily facilitates stability testing. After trial reduction, provocative external rotation is performed with the leg in neutral position and again at 30 degrees of extension. If provocative testing demonstrates anterior instability, intraoperative options that will increase stability include increasing the leg length or offset, using an elevated liner, and socket repositioning. On rare occasions, if stability cannot be achieved without excessive limb lengthening, an elevated liner is used with the elevation at the anterosuperior quadrant.

Discussion

Acetabular component positioning is a critical element in achieving a stable and durable THA. Guidelines for cup positioning have been described in the literature; however, the reliability of the “safe zone” has been recently called into question [7]. An analogous safe zone for the anterior approach has not yet been described, although it has been suggested that optimal anteversion may be less than that of the PA [2].

In our experience, cups positioned via anterior approach while using anatomic and sizing guidelines popularized by the PA were larger, more anteverted, and more likely to dislocate anteriorly in the early postoperative period due to posterior overhang and neck-socket impingement (group A). Through a PA, additional socket coverage of the femoral head in the posterosuperior region has potential value in preventing posterior dislocation, and anterior dislocation is less likely with a proper preserved anterior capsule and restoration of offset and anterior capsule tension. Both hips that dislocated did so while standing on the affected leg and turning away, with extension and external rotation. In both cases, revision was performed by adding an elevated liner in the anterior superior position and increasing the neck length of the prosthetic head. Provocative testing in extension and external rotation demonstrated the stability achieved, and no further dislocations occurred. This experience has highlighted the importance of provocative testing in every case to understand the soft tissue tension achieved.

When cup position was modified based on intraoperative stability testing (group B), anteversion was notably less, although a significant proportion of patients developed iliopsoas impingement

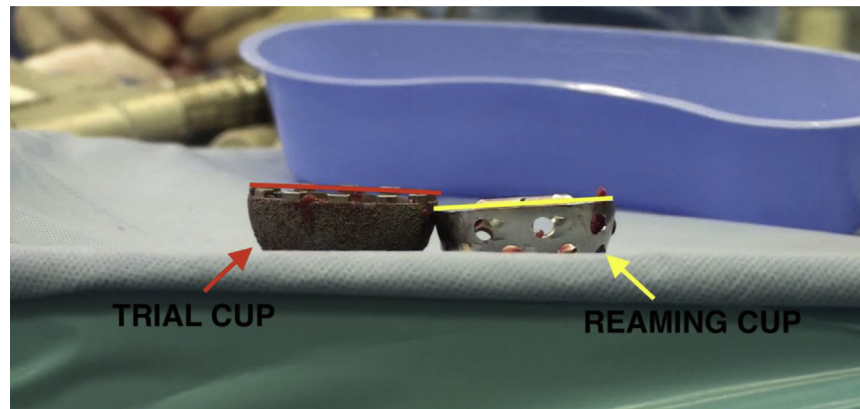


Figure 5. The walls in the trial cup are noticeably longer. The trial cup is a more complete hemisphere than the reamer cup. As such, the ellipse created by the actual socket will be slightly larger than the ellipse created by the reamer. The red line and yellow line mark the top of the socket for the trial cup and reamer cup, respectively, illustrating the difference in length.

due to anterior overhang. Iliopsoas impingement after THA is an uncommon complication, with most of the cases in the literature involving a PA. Therefore, it was troublesome to discover nearly 14%

of patients in our second group of hundred direct anterior THAs developed groin pain. We attributed this high rate of a relatively uncommon complication to anterior overhang of the prosthesis. The diagnosis was made by physical examination of resisted flexion in a seated position, which reproduced the pain, and confirmed with a diagnostic injection of lidocaine and steroid into the psoas sheath [8]. In the overall groin pain cohort of 16 patients, 10 achieved at least partial symptomatic improvement with conservative measures, 5 improved with arthroscopic psoas release, and one patient underwent revision of the socket. In the third group (group C), anteversion was unchanged compared with group B; however, a more anatomic cup sizing strategy was used. This resulted in a drastic decrease in the incidence of groin pain (2.1% vs 13.6%), which is more consistent with the incidence of groin pain with other surgical approaches [9].

At the crux of our cup positioning and sizing strategy is an understanding of the anatomic constraints of the native acetabulum. The anterior wall provides a natural barrier between the iliopsoas tendon and the prosthesis. Positioning the anterior edge of the cup at or behind the anterior wall will reduce the likelihood of psoas irritation. This will effectively set the cup anteversion equal to the patient's native acetabular version but does not in itself guarantee stability. One must also be mindful of the degree of posterior cup overhang, which may result in femoral neck impingement and subluxation or frank dislocation of the hip anteriorly. If the anterior point remains fixed, increasing the cup size will result in greater posterior overhang (Fig. 7). For this reason, we advocate choosing a cup size within about 2 mm of the patient's native cup size. We have found the use of such a strategy results in posterior overhang of less than 3–4 mm and reduces the likelihood of posterior impingement in most cases.

There are some limitations to the described cup sizing and positioning strategy. It is not an infallible approach guaranteed to eliminate instability and psoas irritation. It does not factor in patient-specific considerations such as capsular laxity, flat back, fixed pelvic deformity, excessive acetabular anteversion, or generalized ligamentous laxity, which may predispose the patient to instability. These factors may dictate intraoperative modification in leg length, offset, and socket position to customize to individual anatomy.

Summary

We have found that the optimal cup position and size for DAA THA are different than those for the PA. Following a sound

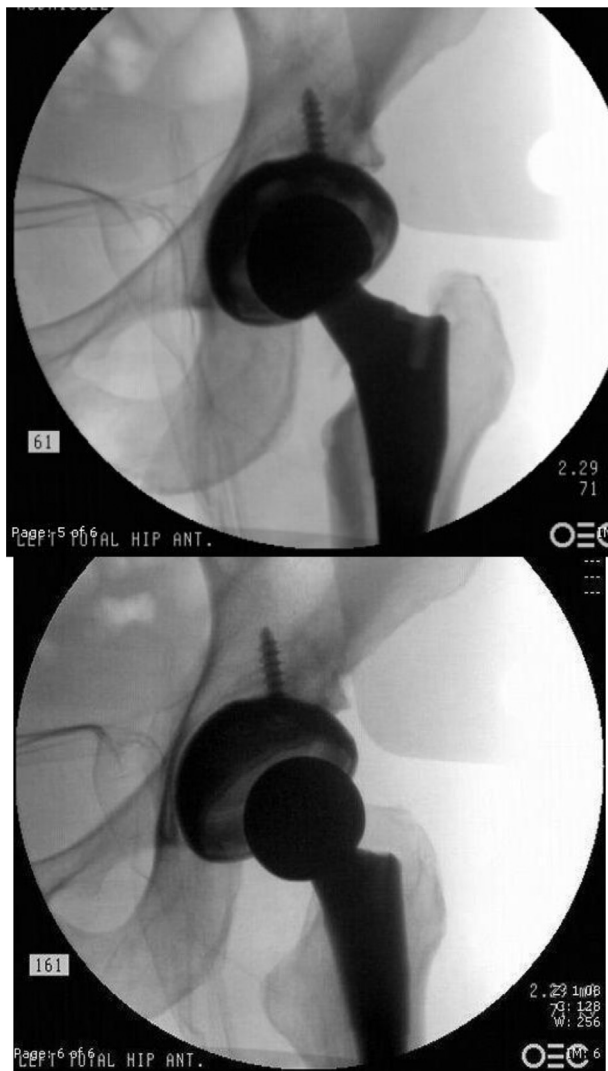


Figure 6. Intraoperative dynamic fluoroscopy examination in a patient with recurrent dislocations demonstrates excessive posterior cup overhang and anterior subluxation with provocative external rotation testing due to posterior impingement.

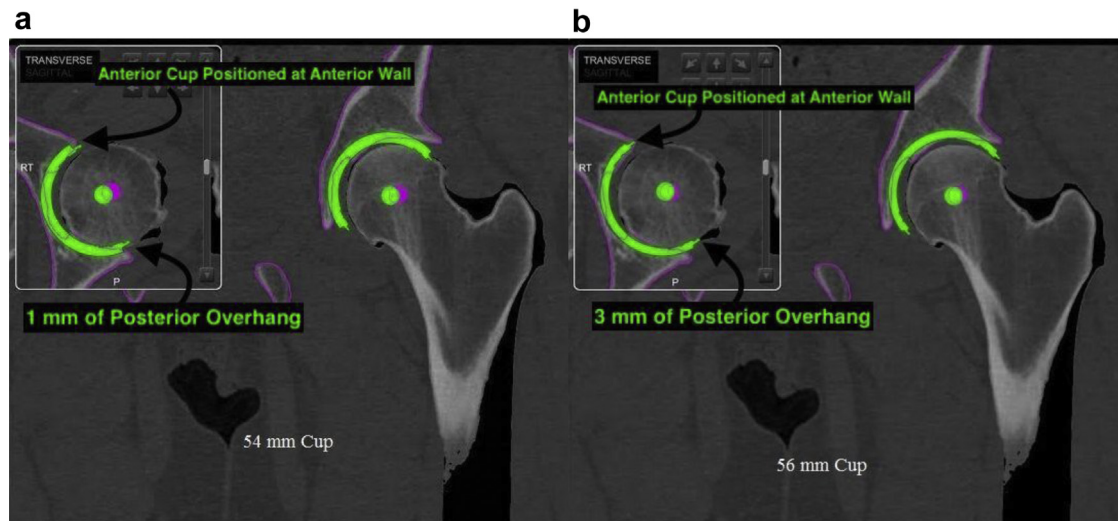


Figure 7. (a) Computed tomography-based model showing a cup of size 54 mm tucked into both anterior and posterior walls. (b) A 56-mm cup positioned at the same point anteriorly protrudes posteriorly to a greater degree.

anatomically based cup sizing and positioning strategy, augmented by the patient's specific considerations and assessed with provocative testing, we were able to reduce the likelihood of the problems associated with a malpositioned acetabular component.

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